UNITED STATES ARMY AVIATION BOARD
Fort Rucker, Alabama

ATBG-SEC AVN 2461.1/62

24 NOV 1961

SUBJECT: Project No. AVN 2461.1/62, "High Altitude Evaluation of the Bell 47G-3B Helicopter"

Commanding General
United States Continental Army Command
ATTN: ATDEV
Fort Monroe, Virginia

1. AUTHORITY.

a. Directive. Letter, ATDEV-6 452.1, Headquarters, USCONARC, 13 January 1961, subject: "Evaluation of the JH-13K."

b. Purpose. To conduct an evaluation of the Bell Model 47G-3B during operation at high elevations to determine whether this helicopter warrants further Army interest.

2. BACKGROUND.

a. By agreement between Bell Helicopter Corporation and the Army, the last two helicopters of the FY 60 H-13H production were to have been equipped with Franklin 6VS-335 turbosupercharged engines in lieu of the standard Lycoming VO-435 engine. In addition, both helicopters were to have been modified to increase the rotor diameter two feet, and to increase the fuselage length 14 inches. These helicopters were to have been designated JH-13K's, and one was to have been delivered to this Board for evaluation as directed above. However, a slightly modified commercial 47G-3 helicopter, equipped with the Franklin 6VS-335 engine, was delivered instead.

b. Since current H-13( ) helicopters utilize Lycoming engines, arrangements were made to evaluate a Bell Helicopter Company Lycoming-powered 47G-3B during the conduct of high-altitude test at Fort Carson, Colorado, during early August 1961.

3. DESCRIPTION OF MATERIEL. The 47G-3B is a product improvement of the 47G-3 with a certificated gross weight of 2850 pounds.

a. The 47G-3B differs from the H-13H in the following significant respects:

(1) The power-plant installation for the 47G-3B helicopter is a Lycoming TVO-435. The engine is equipped with a Marvel Schebler MA-6 Carburetor, and an Air Research Model T-1108 turbosupercharger. This engine is rated at 260 horsepower for two minutes and 220 maximum continuous horsepower, as compared to the 250-horsepower VO-435 engine derated to 200 horsepower installed in current H-13H's.

(2) The supercharger used in the 47G-3B is a typical turbo type. A pressure-temperature sensing device located in the intake manifold actuates a "waste gate" controlling the volume of exhaust gas to the turbosupercharger. This then prevents overboost of the engine and provides sea-level horsepower up to the critical altitude of 15,000 feet.

(3) The center frame is 14 inches longer than that of the H-13H. The configuration has provisions for the installation of the following power plants:

(a) Lycoming Model VO-435 (H-13H Engine)

(b) Lycoming Model TVO-435

(c) Lycoming Model VO-540

(d) Franklin Model 6VS-335 (H-13K Engine)

(4) The main rotor diameter has been increased two feet to 37.125 feet.

(5) The following minor modifications have also been incorporated in the 47G-3B:

(a) The static stop in the main rotor system has been replaced by centrifugally-actuated dynamic flap-restrainers to prevent excessive blade flapping at low rotor speeds.

(b) The transmission has been modified to improve lubrication.

(c) The antitorque rotor pitch-change links and pitch-change horns have been modified to provide increased pitch to the tail-rotor blades.

(d) Straight landing gear cross tubes are used in lieu of the curved tubes in the H-13H. The skid tube-wall thickness has been increased and the length shortened nine inches forward of the front cross tube to meet FAA structural requirements.

(e) The cyclic control has a variable, spring-loaded pressure plate at its base which allows it to be pre-positioned. Thus it is similar to a trim device. The pressure is such that when the cyclic pressure forces are light, the helicopter can be flown "hands off."

(f) An electric boost fuel pump is provided in addition to the engine-driven fuel pump. A light is mounted on the instrument panel to indicate failure of the electrically-driven boost fuel pump.

(g) The bubble and doors are blue-tinted plexiglass. The doors incorporate sliding windows.

(h) Two electric fans have been installed in the cockpit.

b. The 47G-3B Helicopter as tested was provided with the following equipment:

(1) A cargo sling kit of 1000-pound capacity.

(2) A rotor brake.

(3) Two external litters.

4. TESTS. The Bell 47G-3B was picked up at Bell Helicopter Company plant in Fort Worth, Texas, by Army Aviation Board pilots and flown to Fort Carson, Colorado, for high altitude test. These tests were conducted during the period 1 August to 7 August 1961. Tests were oriented primarily toward determining the high altitude operational capability of the helicopter.

a. Physical Characteristics.

(1) Weight Comparison.

(a) The manufacturer reports the following with respect to the weight differential between an H-13H and the 47G-3B: "The empty weight of the H-13H is 1777 pounds and the 47G-3B when equipped with communication equipment, heavy duty battery, first aid kit, shoulder harness, night flying kit, heavy duty ignition harness, electrical wiring, etc., comparable to that in the Model H-13H is 1913 pounds."

(b) Based on the above the following weights have been computed:

	H-13H	47G-3B
1. Basic* (lb.)	1779	1915
2. Allowable gross (lb.)	2450	2850
3. Useful load (lb.)	671	935

* Includes trapped fuel and oil.

(2) Cockpit Configuration.

(a) As compared to an H-13H, the glare and heat have been reduced by using the tinted plexiglass bubble and doors. Ventilation and defogging were improved by the use of the electric fans and the sliding windows.

(c) The boost-fuel-pump amber warning light, mounted low on the left side of the instrument panel, is not readily visible to either pilot or copilot.

b. General Characteristics.

(1) Starting. Starting was normal at density altitudes of 1,000 feet to 11,000 feet.

(2) Hovering Flight.

(a) Hovering flight, in ground effect with an external load at a gross weight of 2850 pounds, was conducted atop Pikes Peak (14,110 feet m.s.l.) at a density altitude of approximately 15,000 feet under light and variable wind conditions. The helicopter was hovered, under the same atmospheric conditions, out of ground effect above Pikes Peak at a gross weight of 2500 pounds.

(b) Hovering flight of the 47G-3B at a gross weight of 2850 pounds with external loads in and out of ground effect was conducted at Butts AAF, Fort Carson, Colorado, at a density altitude of approximately 9,000 feet. As a comparison, H-13H helicopters operating in the same area were unable, with full throttle, to hover in ground effect at a gross weight of approximately 2400 pounds.

(3) Takeoffs and Landings.

(a) Normal takeoffs and landings were readily accomplished. In comparison with the H-13H the 47G-3B had a faster rate of climb and a slower rate of descent at comparable indicated airspeeds.

(b) Control response was comparable with that of the H-13H during takeoffs and landings. However, throttle correlation in the 47G-3B was not good. This was attributed partially to the reaction of the turbosupercharger and partially to throttle rigging. During tests, no adjustments were made to the throttle rigging to improve correlation.

(4) Cruising Flight.

(a) The following indicated cruise speeds were considered normal at a gross weight of 2750 pounds and the density altitudes shown below:

Speed		
Knots	M.P.H. *	Density Altitude (ft.)
69	80	1,000 - 4,500
61	70	4,500 - 10,000
43 - 52	50 - 60	10,000 - 15,000

(b) The helicopter, at a gross weight of approximately 2500 pounds, was flown at maximum permissible indicated airspeeds as shown below:

Speed		
Knots	M.P.H.*	Density Altitude (ft.)
91	105	Sea level to 10,000
61	70	15,000

* Airspeed indicator and flight handbook present data in miles per hour.

(5) Autorotative Descents and Landings.

(a) With the gross weight at 2500 pounds, autorotative landings were made at density altitudes up to 11,000 feet. Performance of the 47G-3B was superior to that of the H-13H; this was attributed to the larger rotor blades.

(b) Hovering autorotations were made at density altitudes from 6,900 to 11,000 feet, and engine stoppage resulted each time. However, when the throttle was closed slowly, the engine idles satisfactorily at these altitudes. (It is understood that the manufacturer has eliminated this problem.)

(6) Slope Landings. Landings on slopes up to 10 degrees were accomplished. There was no significant difference in performance of the H-13H and the 47G-3B.

(7) Turbulence. In-flight turbulence was encountered at density altitudes varying from 7,000 to 15,000 feet. On several occasions, retreating blade stall occurred. Control in blade stall was positive and recovery easily effected by reducing airspeed. Overall handling characteristics in turbulence were considered excellent.

(8) Vibrations. No excessive vibrations were found during any phase of testing. Compared to the H-13H, the 47G-3B was a much smoother helicopter in all regimes of flight reported above.

(9) Engine Shut-Down. Engine shut-down was normal.

(a) By decreasing blade droop at low rotor r.p.m., the centrifugally-operated dynamic flap-restrainers greatly reduced hazards to personnel and reduced the possiblity of the main rotor blade's striking the tailboom.

(b) The rotor brake decreased hazards to personnel and equipment by providing positive and rapid rotor deceleration from 100 r.p.m. to zero r.p.m.

d. Transition Training.

(1) Pilot. Transition training in the 47G-3B can be accomplished by qualified H-13( ) pilots in approximately one hour.

(2) Mechanic. No additional training would be required for H-13( ) qualified helicopter mechanics for airframe and airframe dynamic component maintenance. A short period of on-the-job training would be sufficient for transition to the turbosupercharged engine.

e. Tactical Suitability.

(1) The 47G-3B provides advantages over the H-13( ) in performance of tactical missions by virtue of its increased payload and excellent performance capabilities at density altitudes up to 15,000 feet.

(2) Using a cargo sling, external loads of 400 pounds were flown without difficulty.

(3) The 47G-3B was examined to determine its potential armament capabilities. This examination revealed that, from a standpoint of configuration, weight-carrying capability, and available horsepower, the 47G-3B would accept the XM-1 machine gun kit.

f. Deficiencies and Shortcomings. All deficiencies and shortcomings reported in Report of Test, Project No. AVN 355, "Service Test of YH-13H Helicopter," 24 August 1956; Report of Test, Project No. AVN 2856, "Test of Production Model H-13H Helicopter," May 1957; and Report of Test, Project No. AVN 1960, "Evaluation of Modified H-13H Helicopter," are either not applicable or have been corrected in the 47G-3B. No deficiencies were encountered; however, the following are considered shortcomings of the 47G-3B:

Shortcoming	Suggested Corrective Action
(1) The electric fuel-boost-pump warning light is not readily visible to either pilot or copilot.	Move the warning light to a position readily visible to the pilot and copilot.
(2) The throttle correlation is poor.	Improve throttle correlation.
(3) Rapid throttle closure resulted in engine stoppage at high density altitudes.	Install a carburetor capable of preventing engine stoppage when the throttle is closed rapidly.

5. DISCUSSION.

a. Since the Army normally operates in atmospheric conditions well above those of sea level standard, the primary advantage of a supercharged engine such as installed in the 47G-3B Helicopter is that the engine will develop sea-level horsepower at high altitudes. A further advantage of the 47G-3B Helicopter is its increased payload and ability to carry this payload at high elevations and density altitudes.

Under conditions such as were experienced at Fort Carson, the 47G-3B could be flown with two pilots aboard and an external load of 400 pounds, whereas the Army H-13H could barely be flown with only a pilot aboard and no cargo. Therefore, the 47G-3B not only provides more horsepower and payload capacity for use in the Army environment, but would be particularly suited for operation in areas where high elevations are habitually encountered.

b. Reference is made to paragraph 4a(1) above and the useful load of the 47G-3B (935 pounds) as compared to the useful load of the H-13H (671 pounds):

(1) The installation and utilization of armament (the XM-1 machine gun kit) on the H-13H required exceeding the allowable weight and horsepower limits; the 47G-3B with its increased payload can easily accommodate the XM-1 machine gun kit without exceeding the allowable horsepower or weight limitations.

(2) Utilization of the full payload capacity of the 47G-3B configuration requires distribution of the load near the center of gravity. This can best be accomplished by installation of external armament kits or by use of an external sling to transport high-priority supplies or light equipment. It is considered that the ability to transport external sling loads allows full utilization of the increased payload capability of the 47G-3B and enhances the tactical suitability of the helicopter.

c. Remanufacture of the Army H-13H Helicopter to a military version of the 47G-3B is feasible and would be relatively simple to accomplish. Primary modifications to the airframe would be extension of the center frame and installation of longer rotor blades. Since the power plants of the H-13H and 47G-3B Helicopters are basically the same, conversion of the VO-435 engine to the TVO-435 can be accomplished easily and economically at engine overhaul. It should be noted that any remanufacture program must include both engine and airframe modification since installation of the supercharged engine is required to provide the increased power for better performance, and the larger rotor is required to take full advantage of the additional power available. The longer rotor blades also improve the autorotational characteristics of the modified helicopter at the higher gross weights and altitudes at which it will be able to fly.

d. Paragraph 3a(5) above lists minor modifications which have been incorporated in the 47G-3B. Following are comments as to the desirability of incorporation of these features in future procurement of, or remanufacture to, a military version of the 47G-3B:

ITEM	COMMENT
(1) Centrifugally-actuated dynamic flap-restrainers.	This is a highly desirable product improvement and safety feature that should be incorporated on future procurement or remanufacture.
(2) Modification of transmission to improve lubrication.	This is a highly desirable product improvement that should be incorporated on future procurement or remanufacture. Bell Helicopter Company advises that this modification can be easily incorporated at transmission overhaul.
(3) Modification of antitorque pitch-change links and pitch change horns.	Modification is required with the supercharged engine in order to provide adequate control at high altitude. This modification should be included on any future procurement or remanufacture.
(4) Straight landing gear tube in lieu of curved tube.	Change is not desirable. It is understood that an undesirable weight penalty of approximately 25 pounds results from this change.
(5) Variable, spring-loaded pressure plate for cyclic control.	Modification improves suitability by permitting "hands off" flight and should be incorporated on any future procurement or remanufacture.

ITEM	COMMENT
(6) Electric fuel boost pump and light.	Item is required for supercharged engine to meet FAA standards.
(7) Tinted plexiglass and sliding windows.	This is a desirable change previously recommended by the Board. These items should be included on future procurement but not required on remanufacture unless the bubble and door plexiglass require replacement.
(8) Two electric fans.	These are nice-to-have items but are not required.

e. Paragraph 3b above lists additional equipment provided with the test helicopter. Following are comments with respect to these items:

ITEM	COMMENT
(1) Cargo sling kit.	The desirability of a cargo sling kit is discussed in paragraph 5b above.
(2) Rotor brake.	This is a highly desirable item with the longer rotor blades for "shut down" under gusty conditions. However, provided the centrifugally-actuated dynamic flap-restrainers are installed, the rotor brake is not required.
(3) External litters.	Current H-13H's can already accept external litters if desired.

6. CONCLUSIONS.

a. The Bell 47G-3B Helicopter is superior to the H-13( ) helicopter for performance of tactical missions because of its increased payload and its ability to operate at gross weight at high density altitudes.

b. Product improvement of the H-13H by remanufacture to a military version of the 47G-3B is feasible and would make the H-13( ) more suitable for Army use, particularly for operation in areas of high elevation and high density altitudes and in an armament role.

c. The addition of a cargo sling would increase the capability of a military version of the 47G-3B.

d. The 47G-3B configuration permits installation and utilization of existing armament (XM-1 Kit) without exceeding allowable weight or horsepower limits.

7. RECOMMENDATIONS. It is recommended that:

a. Future procurement of observation-type helicopters, prior to availability of the Light Observation Helicopter (LOH), be a military version of the Bell 47G-3B configuration.

b. Any remanufacture of H-13( ) helicopters provide for conversion to the military version of the 47G-3B.

c. The shortcomings listed in this report be corrected prior to procurement of a military version of the 47G-3B helicopter as a Standard Army helicopter.

8. REFERENCES.

a. Letter, ATBG-SEC AVN 2461, US Army Aviation Board, 2 October 1961, subject: "Report of Project No. AVN 2461, 'Evaluation of the Bell Model 47G-3B (JH-13K) Helicopter'."

b. Model 47G-3B Maintenance and Overhaul Instructions, Bell Helicopter Co., 15 June 1961.

c. Model 47G-3B Flight Manual, Bell Helicopter Co., 24 May 1961.

d. Report of Test, Project No. AVN 1960, "Evaluation of the Modified H-13H Helicopter," US Army Aviation Board, 9 June 1960.

e. Report of Project No. AVN 3257, "Comparative Evaluation of H-13H and H-23D Helicopters," US Army Aviation Board, February 1958.

f. Report of Test, Project No. AVN 2856, "Test of Production Model H-13H Helicopter," May 1957, US Army Aviation Board.

g. Report of Test, Project No. AVN 355, "Service Test of YH-13H Helicopter," Board No. 6, USCONARC, 24 August 1956.

h. Preliminary Operator's Manual, Lycoming Model TVO-435-AIA Aircraft Engine, Lycoming Div., AVCO Corp., undated.

i. Letter, Bell Helicopter Company, 14:CEM:ph-099, 3 November 1961, to US Army Aviation Board, Fort Rucker, Alabama.

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